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DISPLAY APPARATUS

Background of the Invention

The invention is based on a display apparatus according to the species defined in the main claim. Display apparatuses in vehicles, in which a virtual image visible to an observer is generated by the fact that light is projected by a projection unit onto a mirror-coated surface, are already known. In this context, a virtual image visible to a viewer is created behind the plane of the mirror. A unit for light generation and projection that is necessary for this purpose is generally arranged in the dashboard of the vehicle, i.e. behind the steering wheel and below the windshield. Vehicle data in particular, e.g. the present vehicle speed, are displayed in such a display. On the one hand the windshield, or on the other hand additional reflective elements (called combiners), are used as the reflective surfaces onto which the virtual image is projected.

Advantages of the Invention

The display apparatus according to the present invention having the features of the principal claim has, in contrast, the advantage that instead of the virtual image, a real image is generated. Projection of a real image makes it possible to eliminate the image distortion that occurs upon projection of a virtual image, since the real image is preferably projected directly onto a display surface in a manner visible from several directions. It is particularly advantageous in this context to arrange a projection apparatus in space-saving fashion on a vehicle roof or on a vehicle inside mirror. It is advantageous here that for projection of the real image, projection is performed onto a display surface outside the windshield, since as a result it is no longer necessary to cover the windshield -- which otherwise is merely reflective or transparent -- with, for example, a light-diffusing film for projection of the real image. It is moreover particularly advantageous that because the projection unit is arranged on

the vehicle roof or on the vehicle inside mirror, there is no need for model-specific configuration of the vehicle dashboard with a receptacle for a projection unit in the dashboard unit.

The features set forth in the dependent claims make possible advantageous developments and improvements of the display apparatus described in the main claim. It is particularly advantageous to arrange a structural pattern on the display surface. This structural pattern causes the light directed onto the display surface to be directed in a preferred direction. This preferred direction is generally the viewing direction of a viewer, for example a driver of the vehicle. The power level of the light radiated onto the display surface can thereby be decreased with no change in the reading brightness. Targeted light deflection can moreover, for example, prevent dazzling of oncoming traffic or of a passenger.

It is furthermore advantageous to arrange adjacently to the display surface a reflective surface that serves to display a virtual image. Projection of the image onto the windshield can thereby be accomplished as applicable. This is advantageous in particular if an image superimposed on the road scene is to be displayed on the windshield.

It is furthermore advantageous to configure the display surface with a roughened surface, since this makes possible good legibility of the real image if the roughening has sufficient grain.

It is furthermore advantageous to embody the display surface with a holographically introduced structure, which makes possible efficient, low-loss light deflection.

It is furthermore advantageous to arrange on the display surface a surface having a prism structure and/or sawtooth structure, with which the light can efficiently be deflected in a selected direction.

It is furthermore advantageous to embody the display surface as a first and a second surface portion, in which context light can be deflected to a first viewer by way of the first surface portion and to a second viewer by way of the second

surface portion, so that it is possible for two viewers of the display apparatus to view different images. For example, while a second viewer is viewing an entertainment program, information about the vehicle, e.g. the vehicle speed or engine speed, is being displayed to a first viewer, for example the driver.

It is furthermore advantageous to equip the projection unit with a laser beam generation unit and to generate an image by way of laser beams, a deflection of the laser beams being accomplished preferably with mirrors. A bright real image can thereby be generated. It is also possible to dispense with a lens optical system for image generation and projection in the projection unit.

It is furthermore advantageous to provide the projection path approximately parallel to the windshield, since in a region close to the windshield the light path generally is not interrupted by a user of the vehicle.

Drawings

Exemplary embodiments of the invention are depicted in the drawings and explained in more detail in the description which follows.

In the drawings:

Figure 1 shows a first embodiment of a display apparatus in a vehicle.

Figure 2 shows a further exemplary embodiment of a display apparatus according to the present invention.

Figure 3 shows an arrangement of various electronic elements of a display apparatus according to the present invention.

Figure 4 shows a first exemplary embodiment of a projection unit according to the present invention.

Figure 5 shows a further exemplary embodiment of a projection unit according to the present invention.

Figures 6a and 6b show a first exemplary embodiment of a configuration according to the present invention of a display surface.

Figures 7a and 7b show a further exemplary embodiment of a display surface according to the present invention.

Figure 8a shows an exemplary embodiment of a configuration according to the present invention of a virtual image.

Figure 8b shows an exemplary embodiment of a configuration of an outer surface of the display surface.

Description of the Exemplary Embodiment

The display apparatus according to the present invention can be used to display a variety of images and data in a vehicle. In addition to vehicle parameters such as, for example, engine speed, vehicle speed, and/or the ambient temperature of the vehicle, it is also possible to display the image from a camera, e.g. the image from a rear or side camera as well as the image from an infrared camera. Display of the image acquired by the infrared camera, in particular, allows a vehicle user to obtain a good overview of the road even when visibility conditions are poor, e.g. in fog or darkness. In addition, the display apparatus can also serve as an output unit of a navigation apparatus for display of a route to be traveled. In a preferred embodiment, a display surface is arranged at least in the vicinity of the windshield, and is readable by a driver of the vehicle and by a passenger. Also possible is an arrangement of a display apparatus according to the present invention in such a way that a passenger who is not in the first row of seats of the vehicle can read the display, for example by the fact that a display surface is arranged directly in front of a user's seat. All that is necessary for this purpose is to provide a corresponding projection unit for that display surface at a suitable location on the vehicle roof.

Figure 1 shows a first exemplary embodiment in which a projection unit 1 is arranged on a vehicle roof 2. A display surface 4 is arranged on a mount 5 on an instrument panel 3. A light beam 6 that is radiated from projection unit 1 to

display surface 4 is deflected by display surface 4 in the direction of a user, as depicted by an arrow 7. Instrument panel 3 is adjacent one on side to a windshield 8 that extends from instrument panel 3 to vehicle roof 2. Instrument panel 3 encloses a dashboard (not shown in further detail in Figure 1) of the vehicle. A steering wheel 9 is also arranged on instrument panel 3.

In a preferred exemplary embodiment, projection unit 1 is mounted immovably on vehicle roof 2. A voltage supply line and a data line, through which the image data to be displayed are transmitted to projection unit 1, are not depicted in Figure 1. In a preferred exemplary embodiment, the voltage supply line and the data line are integrated into vehicle roof 2 in a manner not visible to a user, and are guided out of the vehicle roof through a door frame. Light beam 6 that passes from projection unit 1 to display surface 4 extends approximately parallel to windshield 8. A driver generally does not reach into this region, so that light beam 6 is not interrupted by the driver. In a first exemplary embodiment, display surface 4 is embodied as a diffusing display surface, which is constituted e.g. by roughening an outer surface of a transparent plastic material. Display surface 4 is a highly reflective surface that is as white as possible and, in a first exemplary embodiment, is covered with a surface material that exhibits approximately the properties of a Lambert radiator. In a preferred exemplary embodiment, display surface 4 is constituted by a suitable film that is applied onto mount 5. Mount 5 is moreover adjustable as to its angle of inclination, so that the direction of the observer (arrow 7) can be set by tilting mount 5 to the observer's eye level. In a further preferred exemplary embodiment, display surface 4 is covered with a film that allows directed emission of the light. This prevents light from being emitted, for example, toward the windshield.

Figure 2 depicts a further exemplary embodiment of a display apparatus according to the present invention. Here and hereinafter, identical reference characters designate identical elements. In the exemplary embodiment depicted in Figure 2, a projection unit 10 is arranged on an inside mirror 11. A mirror surface 12 of inside mirror 11 is arranged on a side of inside mirror 11 facing away from windshield 8. Mirror

surface 12 conceals projection unit 10 from a user as completely as possible, so that projection unit 1 is not visible to a user of the vehicle and thus is not intrusive.

Figure 3 depicts an electrical circuit of a display apparatus according to the present invention. Signals of a video camera 21 and from vehicle sensors 22 are acquired by a control unit 20. The signals of video camera 21 and vehicle sensors 22 are processed in control unit 20 and forwarded for display to an image processing unit 23. In a preferred exemplary embodiment, image processing unit 23 has a digital filtration and calculation unit 24 with which the image signals acquired by video camera 21 are optionally digitally processed, and with which the vehicle variables ascertained by vehicle sensors 22, e.g. vehicle speed, engine speed, and/or outside temperature, are converted into a visual depiction. Image processing unit 23 furthermore has an activation unit 25 that transmits image data to projection unit 1 and controls projection unit 1. In a preferred exemplary embodiment, video camera 21 is arranged behind a radiator grille at the front end of the vehicle, thus making possible unobtrusive observation of the area in front of the vehicle. In a further exemplary embodiment, video camera 21 is arranged in the interior of the vehicle, preferably in the region of the inside mirror, so that observation of the road is performed from the interior of the vehicle. Vehicle sensors 22 are arranged in the vehicle at suitable points provided therefor. In a preferred exemplary embodiment, control unit 20 and image processing unit 23 are arranged in the dashboard of the vehicle or in vehicle roof 2. In a preferred exemplary embodiment, video camera 21 is embodied as an infrared camera, with which image acquisition is possible even in poor visibility conditions such as darkness and/or fog.

Figure 4 depicts a first exemplary embodiment of a projection unit 1. A first laser unit 31, a second laser unit 32, and a third laser unit 33 are arranged in a housing 30. First laser unit 31 produces red light, second laser unit 32 green light, and third laser unit 33 blue light. In a preferred exemplary embodiment, the laser units are embodied as semiconductor lasers or solid-state lasers. A first laser beam 41 of first laser unit 31 can be emitted onto a first mirror 51, with which first laser beam 41 is deflected toward display surface

4. Similarly, second laser beam 42 can be directed onto a second mirror 52, and third laser beam 43 onto a third mirror 53. Mirrors 51, 52, 53 are modifiable, preferably via piezoelements, in terms of their angle of inclination in two spatial directions about rotation axes lying in the plane of the respective mirror, so that scanning of display surface 4 by laser beams 41, 42, and 43 is ensured by means of the mirrors. The use of the three colors red, green, and blue allows generation of a color image. In an exemplary embodiment that is not depicted in the drawings, instead of the three laser units 31, 32, 33 shown in Figure 4 it is also possible to use only one laser unit of one specific color. This makes possible a monochrome display in the specific color. In a further exemplary embodiment not depicted in the drawings, light deflection is accomplished with a micromechanical mirror display (DMA = digital mirror display).

Figure 5 shows a further exemplary embodiment of a projection unit according to the present invention. A light source 44 preferably emitting white light, e.g. a halogen light source, is arranged in a housing 40. The light of light source 44 can be emitted through a liquid crystal cell 45 and through a lens 46 toward display 4. Liquid crystal cell 45 comprises individual image points whose light transmission can be influenced by an electrical activation system (not shown in Figure 3). By appropriate activation of the image points, an image can be generated by liquid crystal cell 45. The spacing between liquid crystal cell 45 and lens 46 is selected, in conjunction with the focal length of lens 46, in such a way that the image generated by liquid crystal cell 45 is imaged onto display surface 4. Both the projection unit shown in Figure 4 and that shown in Figure 5 can be used as a projection unit 1 on the vehicle roof or as a projection unit 10 on an inside mirror.

In a first embodiment, display surface 4 is configured as a flat surface. In an exemplary embodiment not depicted in the drawings, display surface 4 can be protected from soiling or damage by a fold-down cover. Figures 6a and 6b show a further exemplary embodiment of a semi-spherical display surface 50. Semi-spherical display surface 50 is embodied as a semi-spherical elevation above instrument panel 3. Figure 6a shows a view from the direction of the viewer at the height of

instrument panel 3. Figure 6b shows a plan view onto semi-spherical display surface 50 from the position of projection unit 1 or 10. The semi-spherical configuration makes possible display of an image over a wide spatial angle. As a result, an image can be seen both by a driver of the vehicle and by a passenger. It is moreover also possible for a passenger sitting farther back in the vehicle to read from semi-spherical surface 50, which preferably is covered with a light-diffusing film or a light-diffusing layer. To ensure that the semi-spherical configuration does not result in distortion of the displayed image, in a preferred exemplary embodiment a prior computational distortion of the image, in which projection onto semi-spherical display surface 50 is taken into account, is accomplished in image processing unit 23.

In Figures 7a and 7b, a display surface is divided into a first surface portion 61 and a second surface portion 62. Figure 7a shows a view onto surface portions 61 and 62 from a viewer's height corresponding to the height of instrument panel 3. Figure 7b shows a plan view from the position of projection unit 1 or 10.

An image for a driver can be projected onto first surface portion 61, and an image for a passenger onto second surface portion 62, so that different images can be displayed for the driver and the passenger. In addition to an embodiment of surface portions (depicted in Figures 7a and 7b) having a triangular base outline, it is also possible to provide surface portions having a rectangular or trapezoidal display surface, or to space the surface portions apart.

Figure 8a depicts a further exemplary embodiment of a display apparatus according to the present invention in which the image projected onto a display surface 4 is deflected by display surface 4 toward windshield 8. A semi-reflective layer 70, with which light is deflected toward observer 7, is provided on windshield 8. Reflection onto semi-reflective layer 70 creates for an observer a virtual image that appears to an observer to be located on the side of windshield 8 facing away from the observer. It is also possible to use a layer that reflects, and deflects to an observer, only light of a defined polarization direction of light beam 6 that is

reflected from display surface 4. A polarization direction of the light emitted from projection unit 1 or 10 must, in this context, be adapted to the polarization direction of the semi-reflective layer, or vice versa. In an exemplary embodiment not depicted in Figure 8a, it is also possible to dispense entirely with a semi-reflective layer and to generate an image solely by way of a reflection at windshield 8. In the exemplary embodiment depicted in Figure 8a, display surface 4 is embodied so as to deflect as much light as possible directly toward reflective surface 70, and as little light as possible directly to an observer, in order to achieve the brightest possible virtual image. The display surface can have a light-diffracting, light-refracting, reflective, or light-diffusing structure, as well as a combination of said structures.

Figure 8b depicts a preferred exemplary embodiment of such a structure. A light beam 6 strikes display surface 4, which is constituted by a first layer 81 and a second layer 82. The boundary surface between first layer 81 and second layer 82 is formed by sawtooth shapes 83. As a result of differently selected refractive indices, total reflection of light beam 6 at the boundary surface between first layer 81 and second layer 82 occurs at an interface from first layer 81 to second layer 82. This makes possible directed light deflection toward a viewer or, depending on the orientation of sawtooth shapes 83, toward reflective layer 70. First layer 81 and second layer 82 are preferably made from a plastic material. In a preferred exemplary embodiment, the structure is introduced into second layer 82 holographically, e.g. by means of laser light. Instead of the sawtooth shapes shown in Figure 8b, symmetrically configured prisms or other structures are also possible, for example an embodiment as a Fresnel lens. In a further exemplary embodiment, prism or sawtooth shapes can also be applied onto an outer surface of a display surface by injection molding.